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ORACH, ITS CULTURE AND USE AS A GREENS CROP IN THE GREAT PLAINS REGION

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INTRODUCTION

Orach (*Atriplex hortensis* L.) is not a new crop, for the records of its culture are found among the earliest botanical writings. At the present time it is widely, though apparently not intensively, cultivated throughout most of the civilized world. In the United States its culture is largely confined to the central Great Plains and intermountain regions, where many people raise it in home gardens as a substitute for spinach (*Spinacia oleracea* L.). Results of trials at Washington, D. C., (*29*)[1] indicate that its chief value there is to furnish a greens crop after spinach has bolted to seed. However, in many sections of the Great Plains and intermountain regions it is virtually impossible to grow spinach, because of environmental conditions that cause seedstalk formation before the plant has made sufficient growth to furnish an edible product. In many sections, too, its short, compact habit of growth renders it susceptible to serious injury from wind-blown sand.

For such places orach possesses several advantages, especially if considered primarily as a home-garden vegetable. It is easily cultivated and stands neglect better than most garden crops. It is exceptionally drought-resistant and is tolerant of alkaline and saline soils. Although it starts seed-stalk formation while still relatively young, it continues to put out large, tender leaves on the upper portions of the plant, thus providing a continuous supply of greens throughout the entire growing season. Moreover, these same plants that are providing the greens will also produce an abundance of seed for the next season. Finally, its upright habit of growth keeps the leaves well above the ground, thus reducing the chances of injury from wind-blown sand and making it easier to clean for culinary purposes.

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[1] Italic numbers in parentheses refer to Literature Cited, p. 20.

HISTORY OF CULTURE

Orach was an important food plant for mankind long before the introduction of spinach. In keeping with the history of many crops that are now grown solely for foods, however, it was first used chiefly for medicinal purposes. The conception that plants might possess both beneficial and harmful properties occurs so frequently in the earlier descriptions of plants that it is often difficult to determine whether certain plants cultivated for food or medicinal purposes were not considered on the whole more baneful than beneficial. One of the most interesting, and a rather typical example, of these earlier descriptions is that furnished by Pliny (*6, pp. 282–283*) in his discussion of orach:

> Orage, again, is found both wild and cultivated. Pythagoras has accused this plant of producing dropsy, jaundice, and paleness of the complexion, and he says that it is extremely difficult of digestion. He asserts, also, to its disparagement, that every thing that grows near it in the garden is sure to be drooping and languid. Diocles and Dionysius have added a statement, that it gives birth to numerous diseases, and that it should never be boiled without changing the water repeatedly; they say, too, that it is prejudicial to the stomach, and that it is productive of freckles and pimples on the skin.
>
> I am at a loss to imagine why Solo of Smyrna has stated that this plant is cultivated in Italy with the greatest difficulty. Hippocrates prescribes it with beet, as a pessary for affections of the uterus; and Lycus of Neapolis recommends it to be taken in drink, in cases of poisoning by cantharides. He is of opinion, also, that either raw or boiled, it may be advantageously employed as a liniment for inflammatory swellings, incipient boils, and all kinds of indurations; and that, mixed with oxymel and nitre, it is good for erysipelas and gout. This plant, it is said, will bring away mal-formed nails, without producing sores. There are some people who give orage-seed with honey for jaundice, and rub the throat and tonsils with it, nitre being added as well. They employ it, also, to purge the bowels, and use the seed, boiled, as an emetic, either taken by itself, or in conjunction with mallows or lentils.
>
> Wild orage is used for dyeing the hair, as well as the other purposes above enumerated.

From this discussion it is seen that the very earliest references to orach deal with its supposedly baneful properties as well as its healing virtues. Later writers discuss its virtues as a medicine, and such discussions in turn give way to references to its value as an article of diet.

Pliny's quotation from the writings of Pythagoras, a Greek philosopher who lived in the sixth century B. C., is evidence that orach was known even at that early period as a cultivated or garden crop. Theophrastus (*23*), Dioscorides (*18*), and other early writers also refer to its culture.

The extent to which orach was cultivated in ancient times is now difficult to determine because of the confusion in names applied to this and similar plants. For example, the name "Athraphaxis" was frequently used by early writers to refer to *Atriplex hortensis*, but it was also applied to *Chenopodium bonus-henricus* L. The latter probably originated in the mountains of the eastern Mediterranean region, apparently in the mountains of Greece; while *A. hortensis* is believed to be native to northern India, or, according to Bryant (*9*), to Tartary.

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By some authors *A. halimus* L. is confused with *A. hortensis*, and according to Moss (*27*) examples of this species found in the British Isles have been erroneously called *A. nitens* L. The mallow mentioned in the Bible as a food plant was evidently an *Atriplex*, but to what species it belonged is not definitely known. There is strong evidence to indicate that the plant referred to was *A. halimus* rather than *A. hortensis*, though Engler and Prantl (*14*) state that according to Goser (Trees and Plants of the Bible, 1895, p. 188) *A. hortensis* is mentioned as an emergency food and by Hiob as a vegetable in Palestine. Smith (*31*), on the other hand, believes that the mallow referred to was *A. halimus*, and Hastings (*20*) calls attention to the fact that two Arabic plant names are derived from the same root—"Melukujeh" and "Mallukh." The first of these refers to the plant known as "Jew's mallow" (*Corchorus olitorius* L.) of the family Tiliaceae. It is used in the manufacture of jute, and the immature stems and leaves are also used extensively in the East as a potherb. Hastings points out, however, that it grows only on well-watered land, and that since "the context of the only passage in which Malluah occurs (Job 30:4) refers to desert places and plants, and to the food the very poorest of the people, this is not likely to be the plant tended." Mallukh, on the other hand, is identical in form with Malluah and with Mullah, an allied form used in some places. Both of these are popular names of the sea orach or sea purslane, *A. halimus*.

Dragendorff (*13*), who seems to have made a considerable study of the matter, furnishes us with the following summary showing the confusion in nomenclature to be found in the earlier references to this crop:

> *Atriplex hortensis* was known to Galenus by this name, but he also knew it as *Atraphaxis* (as well as *Chenopodium Bonus Henricus;* which he also calls *Atriplex agrestis*). Columella speaks of "Atriplicus olus, which the Greeks call Atraphaxyn." Simeon Sethi speaks of Atriplex as Chrysolachanon . . . Galen's alimon corresponds to *A. halimus*. * * * The name melde is understood by H. Hild to refer to Atriplex. Arabian writers refer to it as Quathaf and Sarmaq, possibly also as Radschil eldscharad and *A. odorata Zarnab*.

Thus, while we cannot now determine to what extent orach was cultivated by ancient peoples, we do know that it was widely distributed and that it was a fairly common article of diet.

The methods by which orach was disseminated from its native home on the littoral wastes on the plains of Tartary throughout most of the countries of the civilized world are now but a matter for conjecture. Perhaps that offered by Engler and Prantl (*14*), ascribing it to an advancing world trade and the transport of pelts and wool, is as satisfactory as any.

Evidence that it was in general cultivation in the countries surrounding the Mediterranean by the sixth century B. C. has already been presented. From this region it was introduced into France, where it evidently became an important article of diet and where it is still commonly cultivated (*14*, *33*). By 1548 it was well known in England by Turner (*7*), who says that "it groweth in gardens and in some cornfields." Its importance as a cultivated crop in England was on the increase at least until 1597, when Gerard (*17*) wrote that "there be sundrie sorts of orach, some white; some reddish or deep purple color; and others wild of the field, and also one of the sea." He describes each type and assigns to them the following names: *Atriplex sativa*, the white garden orach; *A. sativa purpurea*, purple orach; *A. sylvestris polyspermum*, the wild orach, or all seeds; and *A. marina*, sea orach. In 1623 Bauhin (*3*) mentioned the red, the white, and the dark-green varieties. By 1686 its popularity was evidently on the decline, for Ray (*30*) mentioned only two kinds, the red and the white. In 1783 Bryant (*9*) reported that orach was "much cultivated in English gardens formerly, but now its place is chiefly supplied by spinach." He added that "the French, however, still esteem it, and there are some palates among us that prefer it to spinach." Sturtevant (*21*) states that "in England, the name spynoches occurs in a cookbook of 1390, compiled under the name of 'The Forme of Cury for the use of the court of King Richard the Second.' " It thus appears that both spinach and orach were cultivated in England as potherbs for a period of about 390 years before the time of Bryant.

Loudon in 1829 (*25*) described only two varieties, but gave rather complete cultural directions for raising the crop. He referred to its culture in France by saying that "in the market gardens round Paris, the plant is often cultivated in the broadcast way, like common spinach." Britten and Holland, writing in 1886 (*8, p. 80*) made no mention of its use as a vegetable, but referred to—

> The leaves of the *Atriplex hortensis*, or garden orach; which dairy women in general sow in their gardens annually for this purpose [i. e. for packing butter in]. They are sufficiently large, of fine texture, and a delicate pale green colour.

This use of orach probably accounts for one of the many synonyms, "butter leaves," by which it is now known. It is not now widely cultivated in England, but some seed houses still list it and recommend it as a good substitute for spinach.

The time of its introduction into North America is not known. Apparently the first reference to its culture in this country is that by McMahon (*26*), who mentioned three kinds as being grown in American gardens in 1806. In 1865 Burr (*10*) gave directions for the culture of the crop and described seven varieties. He stated, however, that at that time it was rarely found in the vegetable gardens of this country. So far as is known, no American seed house now lists orach, and its culture seems to have practically disappeared from the more humid eastern and southern regions. Its relative unpopularity in these sections of the country may have been due to the fact that it came into direct competition with spinach in an environment especially well adapted to the culture of the latter crop.

The culture of orach as a potherb in the central Great Plains and intermountain regions seems now to be increasing, but the method and date of its introduction into these regions are somewhat conjectural. Fox (*16*), in describing a miscellaneous group of garden plants used for salads and greens in Idaho, said that seed of one variety of orach was received from the California Agricultural Experiment Station in 1896. It seems probable, however, that it was introduced into this general region considerably prior to this date, for specimens of it, growing as escapes from cultivation, were found in Logan County, Utah, in 1897.[2] It seems to have been brought into this region chiefly by peoples of central European extraction, and this supposition is in part substantiated by the fact that practically all of the specimens found growing as escapes from cultivation, as well as those found under cultivation, are of the Triumph variety. This variety in its culture and in its seed sources seems to be rather definitely limited at the present time to the central European countries. Orach is now widely cultivated throughout the central Great Plains and intermountain regions as a home-garden vegetable, and several charitable and penal institutions in Wyoming grow it in considerable quantities for their inmates, who prefer it to spinach.

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[2] Specimens sent to Aven Nelson, Rocky Mountain herbarium, University of Wyoming, Laramie, Wyo.

BOTANICAL CLASSIFICATION, DESCRIPTION, AND NOMENCLATURE

Orach belongs to the genus *Atriplex*,[3] of the family Chenopodiaceae, commonly referred to as the goosefoot family. This family also contains the shadscales and saltbushes.

There are about 125 species of *Atriplex* (*34*), found especially in Europe, Asia, and Australia, with a few in Africa and many in North America, especially in the temperate zones. A few are cosmopolitan. Of the 125 species only one, *A. hortensis*, is widely used as a garden vegetable. *A. leptocarpa*, *A. semibaccata*, and others have been introduced into this country as forage plants for arid regions. *A. breweri* is used as a hedge plant in southern California. *A. hortensis* var. *atro-sanguinea* Hort. is sometimes used as an ornamental, and *A. patula* is a common weedy plant throughout the country.

A description and synonymy of orach (*Atriplex hortensis*) follows.

Stem 2 to 3 meters (approximately 6½ to 10 feet) high; leaves petioled; lower leaf blades from cordate or sagittate to long-ovate; margins sinuate to dentate, 1 to 2 dm. (4 to 8 inches) long, the upper tending to become more nearly lanceolate and entire; bracts rounded-ovate, about 1 cm. (about ⅜ inch) in diameter, membranaceous, reticulate.

Synonymy.—Orach, orache, orage, orech, arrach, mountain spinach, tree spinach, tame lambs quarters, butter leaves, French spinach, sea purslane, Good Henry. (The latter name is sometimes erroneously applied to orach, but is correctly applied only to *Chenopodium bonus-henricus* L.). Sea purslane is frequently used to designate *Atriplex halimus*, but is applied to *A. hortensis* by Bailey (*2*) and Nicholson (*28*).

Foreign names.—French, orache, arroche, belle dame; Spanish, armuelle; Dutch, melde, hofmelde; Norwegian, have-melde; German, Gartenmelde, Meldekraut; Italian, atreplice, belle dama; Bohemian, leboda; Arabian, quathaf, sarmaq, and possibly other colloquial terms.

HORTICULTURAL VARIETIES

Although there are several varietal names of *Atriplex hortensis* listed by seedsmen, they may all be classed under four main types. The varieties Triumph, Gelbe, Lee Giant, and Deep Blood Red are described as representing these types, but it is not implied that other varieties listed under a particular type are identical, but rather that they are similar. These varietal descriptions are based on plant characteristics as observed in the central Great Plains region.

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[3] The name of the genus (*Atriplex*), according to Engler and Prantl (*14*), is from the Greek "Atraphaxyn" for twofold and seed, because of the two kinds of seeds. Johnson and Brown (*24*), however, give its derivation as from "ater," black, and "plexus," woven together, "on account of the dark color and habit of some of the species." The Greek name for the genus, "Atraphaxyn," is given by Hereman (*22*) and Nicholson (*28*) as compounded from "a," privative, and "trepho," to nourish.

TRIUMPH

Plant (fig. 1) intermediate in size, 6 to 9 feet; also intermediate in number of branches. Stem and leaf petioles same color as leaves. Leaves dark or grass green, coarsely rugose; lower leaves ovate to cordate; large, with long-tapering, slightly rounded point; margins coarsely and irregularly sinuate two-thirds of length from base; base of leaf broad, and angles between base of leaf and petiole more obtuse than in Gelbe or Deep Blood Red; upper leaves becoming slightly more lanceolate; veins of same color as leaves; more thickly covered with glandular hairs than Gelbe or Deep Blood Red, but less so than Lee Giant. Normal vertical and horizontal seeds yellow brown, but black seeds also borne in both forms. Immature bracts same color as leaves; mature bracts light yellow brown, somewhat lighter than seeds.

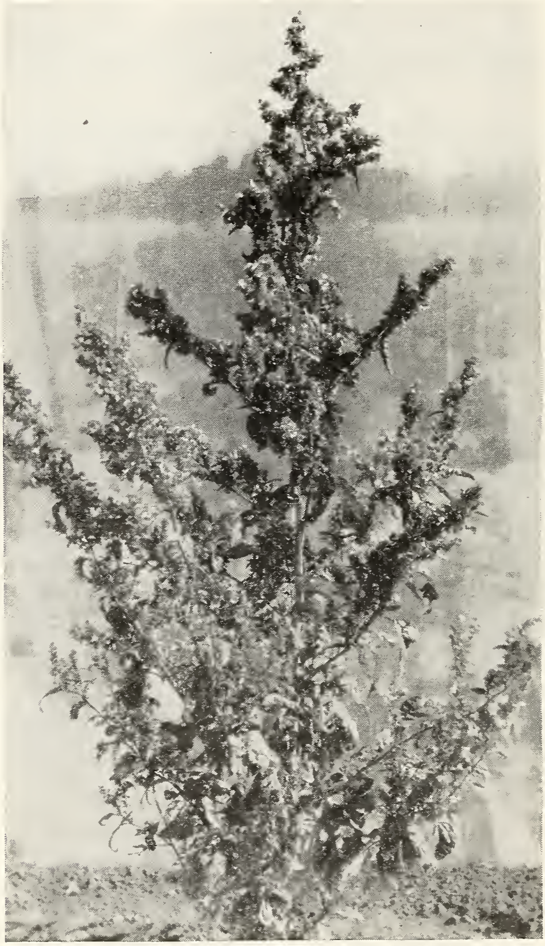

FIGURE 1.—Single plant of Triumph variety.

Triumph is the variety most widely cultivated throughout the central Great Plains and intermountain regions. It is listed by Vilmorin in his 1931 catalog as being a new variety, and insofar as can be determined it is listed at the present time by only one other seed house. Burr (*10*), however, in describing the varieties commonly grown in 1865, described one that, in its leaf characteristics at least, appears to be more nearly comparable to Triumph than to any other variety.

The variety Verte may also be classed with Triumph. Green Double Headed is very similar to Triumph, except that the leaves are typically more rugose and secondary branches near the tips of the primary laterals give it a more dense or shrubby appearance.

GELBE

Plant (fig. 2) intermediate in size, 6 to 9 feet; typically somewhat more branched than Triumph. Stem and leaf petioles same color as leaves. Leaves pale or yellowish green (hence the name "White" under which it is frequently listed); upper surface of leaf covered with light-grayish bloom; coarsely rugose, medium in size, with rounded point becoming progressively more lanceolate toward top of plant; margins of lower leaves coarsely sinuate, approaching dentate; upper leaves more nearly entire; basal angles broad, occasionally closely approximating a right angle with petiole; sparsely covered with glandular hairs on upper surface, intermediate coverage on lower surface. Normal vertical and horizontal seeds yellow brown, but black seeds also borne in both forms. Immature bracts greenish yellow, mature bracts light yellowish brown or somewhat lighter than seed.

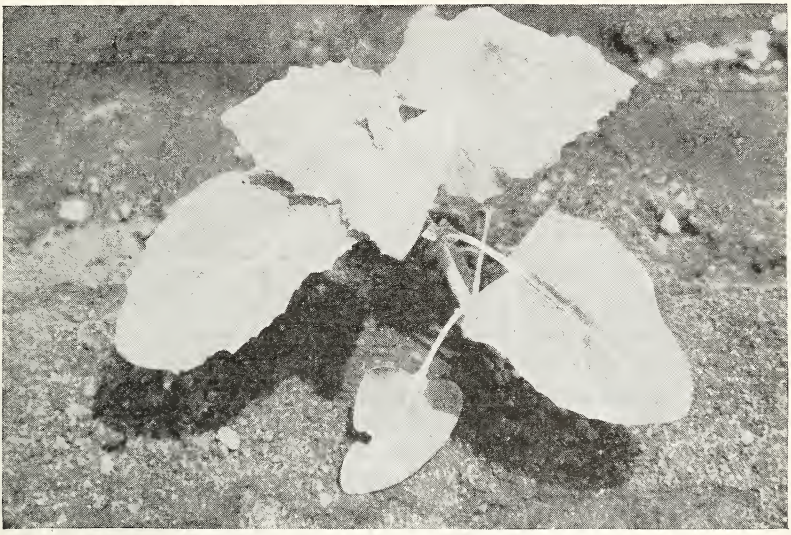

FIGURE 2.—Young plant of Gelbe variety.

Gelbe is more frequently listed by seedsmen in Europe and South America than any other variety; it is also the most popular variety cultivated in France.[4] Two types are sometimes offered. One has leaves that are nearly smooth, whereas the other, under favorable growing conditions, has leaves that are somewhat puckered or savoyed. As listed by seedsmen of various countries, the variety is known under the following names: Gelbe, Blonde, Blonde à feuille cloquée, Giant White, Yellow (White).

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[4] Personal communication from Vilmorin-Andrieux & Cie.

LEE GIANT

Plant somewhat taller (7 to 10 feet) and considerably more branched than other varieties. Stem, leaf petioles, and leaf veins of same color as leaves. Leaves dark green, flat, triangular-hastate, with lower lobes relatively much enlarged; smallest and least fleshy of any cultivated variety; margin coarsely and irregularly dentate; base of leaf forming obtuse angle with petiole; upper leaves very much reduced in size; more thickly covered with glandular hairs on both upper and lower surface than any other variety. Normal vertical and horizontal seeds yellow brown, but black seeds of both types also borne. Immature bracts same color as leaves; mature bracts light yellow brown, or somewhat lighter than the seeds.

This variety is seldom listed by seedsmen and probably owes its relative unpopularity to the small size and thinness of its leaves. In plant and leaf type it more nearly approaches *Atriplex nitens* than any other variety, and it may have been this fact that led Moss (*27*), Hall and Clements (*19*), and others to the conclusion that *A. hortensis* originated from *A. nitens* in cultivation. The seeds of the two species are identical.

DEEP BLOOD RED

Plant smallest and least branched of all types, 4 to 6 feet. Stem, leaf petioles, and leaf veins dark purplish red, darker than leaves. Leaves striped with lighter red and covered with grayish bloom; upper surface dull crimson with slight grayish bloom, lower surface reddish purple with slight grayish overcast; lower leaves cordate, occasionally approaching sagittate; coarsely rugose; margins undulate; basal angles broad, sometimes almost at right angles with petioles, becoming obtuse on upper leaves; leaves toward top of plant becoming more lanceolate and margins less undulate; glandular hairs on leaves not so numerous as on many other varieties. Shape of seed and bracts identical with other varieties. Normal vertical and horizontal seeds reddish brown; vertical and horizontal black seeds also borne. Immature bracts usually reddish green, occasionally pure red. Mature bracts light yellowish brown, identical with other varieties.

Greater variation in color and general plant characteristics appear among the red varieties than in any other group. In color the different varieties range from a reddish green through bright scarlet to those showing an almost purplish color on the exposed surface. Other variants range from those exhibiting either green stems, petioles, and leaf veins with red leaves to those showing red stems, petioles, and leaf veins with reddish-green leaves. Many seed stocks are mixed perhaps as hybrids with green varieties, and exhibit all of these and still other variations.

The following varietal names appear among the list of red varieties: Rouge foncé, Rouge ou pourpre, Roode, Colorado, Giant Red, Deep Blood Red.

CLIMATIC AND SOIL REQUIREMENTS

Orach seems specially well adapted to climatic and soil conditions prevalent in the Great Plains and intermountain regions. Mature plants will attain a height of from 7 to 10 feet when grown under irrigation, and they often exceed a height of 6 feet on dry land. It appears to be better adapted to these regions than to the more humid Eastern States, for, as grown there, the mature plant reaches a height of from 2 to 4 feet (*10*).

In hardiness orach equals or exceeds spinach. Young plants emerging from either an early spring or a late fall seeding will withstand 26° F. without injury. Growth at elevations of from 7,000 to 7,300 feet is only slightly less vigorous than in lower situations. At these higher altitudes night temperatures of from 40° to 50° F. are common during the growing season. Further evidence of the plant's hardiness is found in the fact that as an escape from cultivation it persists as a weed throughout many parts of this region.

Classified by Wolfanger (*35*) as Pedocals (lime-accumulating), the soils of this region are almost without exception either about neutral in reaction or somewhat alkaline. In such soils orach and most other members of the genus *Atriplex* reach their maximum development. As an escape from cultivation orach has been found growing in strongly alkaline and saline situations. It is probable, however, that this is a case of tolerance only, and that for best results it should be planted on soils suitable for the culture of the common garden crops.

WATER REQUIREMENTS

Burr (*10*), in his discussion of the culture of orach in the eastern United States, says that "on dry, arid soil it is comparatively worthless." Such an observation is not at all in accord with results obtained in this region. Under dry-land conditions it will grow to a height of from 4 to 6 feet even in the driest seasons and produce a crop that is little if any inferior in quality to that produced under irrigation. Even in the dry year of 1934, good growth and a product of high quality was reported for a crop grown at the Southern Great Plains Field Station, Woodward, Okla.[5]

Field plantings under irrigation require less water for maximum development than almost any other annual vegetable crop. On the heavier types of soils, if sufficient moisture is present for germination one or two irrigations are sufficient even when the plants are allowed to mature. When only one irrigation is to be given, it should be applied at about the time the first true leaves are forming. If a second application is to be made it will probably be most effective if given when the plants are from 2 to 3 feet high. On the light types of soil a greater number of irrigations may be required to insure maximum vegetative development.

If the entire crop is to be harvested when the plants are from 4 to 6 inches in height, not more than one irrigation will be required, and even this may be unnecessary if the soil is amply supplied with moisture at the time of seeding.

PLANTING

TIME AND CONDITIONS

Orach may be planted as early in the spring as the ground can be prepared. The germination period is the most critical stage of the plant's growth, and if the soil is too cold or wet a poor stand of plants may result. Trials made at Cheyenne, Wyo., indicate that seedings made during the latter part of April and during May give a better stand of plants than those made during June and July.

For an early spring crop, seeding may also be done in the fall of the previous year, and on an average this will result in a slightly earlier crop than the spring plantings. The soil chosen for fall seedings must be as dry as it is possible to obtain, otherwise some of the seed may germinate and subsequently be killed. For regions having climatic conditions similar to those at Cheyenne, the best time to make the fall seeding would probably be between October 15 and November 15.

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[5] The variety under test was Triumph, which was sent to L. F. Locke, associate horticulturist, one of the cooperators in testing this variety.

SPACING AND RATE OF SEEDING

Orach is usually raised from seed sown where the crop is to be grown. It can be readily transplanted, however, and advantage may be taken of this fact in northern sections where late spring frosts are likely to occur.

When it is raised from seed sown where the crop is to be grown, orach is planted in rows spaced from 20 to 42 inches apart. Under dry-land conditions, or under irrigation when the plants are to be grown to maturity, the rows are spaced 42 inches apart. If, however, the plants are to be harvested when from 4 to 6 inches in height, rows are spaced 20 inches apart under irrigation, and they may be so spaced under dry-land conditions if the moisture supply is ample. When the rows are spaced 42 inches apart, from 8 to 16 pounds of seed are used per acre; with the 20-inch spacing, from 15 to 25 pounds per acre are required. For home-garden plantings, from 1 to 2 ounces of seed are sufficient for 100 feet of row space.

The rates of seeding given above apply to cleaned seed or seed from which the bracts have been removed. Commercial seed from the Old World is always sold with the bracts attached. If such seed is used, the rates of seeding will have to be correspondingly larger.

Table 1 shows the relative stand of plants and the yield obtained from various rates of seeding. The trials were conducted on a greenhouse bench, twenty 5-foot plots being used for each rate of seeding. The plots were suitably distributed to eliminate errors due to place effects. Plant counts and yield data were taken for individual plots, but these have been combined for presentation in the table. The plants were harvested when from 4 to 6 inches in height, or at the size most desirable when the whole plants are to be used.

TABLE 1.—*Comparative stands and yields of orach obtained from various rates of seeding per 100 linear feet of row space*

Rate of seeding (ounces)	Plants	Yield	Comparative stands	Comparative yields	Weighted percentage for stand
	Number	*Ounces*	*Percent*	*Percent*	
½	689	39.75	17.78	70.67	106.68
1	1,365	45.75	35.22	81.33	105.66
2	2,775	54.75	71.59	97.33	107.39
3	3,876	56.25	100.00	100.00	100.00

Examination of the data will show that both the number of plants per linear foot of row space and the yield in ounces increased as the rate of seeding increased. However, the ratio between the stand of plants and the yields is not the same for the various seeding rates. If the stand of plants and the yield from the 3-ounce rate is taken as a basis of comparison, it will be noted that the 2-ounce rate with only 71.59 percent as many plants shows a yield 97.33 percent of that obtained from the 3-ounce rate. The corresponding stand-yield ratios for the ½-ounce and the 1-ounce rates appear to be even more favorable. Observations made at the time of harvest, however, show that the plants in the ½-ounce plots were not of the best quality because of their somewhat woody stems. This was also the case with those from the 1-ounce rate, but to a lesser degree. On the other hand, the plants from the 3-ounce plots were somewhat stunted through overcrowding. From these observations it seems that about 2 ounces of seed per 100 feet of row space gives about the maximum yield consistent with high quality.

The column showing the weighted percentages for stand was derived by multiplying the percentage for a given seeding rate by a factor to make it directly comparable with the 3-ounce rate of seeding. It shows that the stand of plants obtained in this trial was roughly proportional to the quantity of seed sown. This is not always the case, however, for where damping-off is an important factor in securing good stands, the stands from the higher rates of seeding are often more seriously injured than those from the lower rates. Only by actual trial can one be certain of the correct rate to employ under various conditions.

DEPTH OF SEEDING

The depth of seeding is of much importance, as poor stands frequently result from covering the seed too deeply. The most favorable depth will be governed largely by the nature of the soil and the quantity of moisture present. In clay or the heavier types of soil the seed should not be covered deeper than one-half inch, and even this may be too deep if much moisture is present and the soil is abnormally either warm or cold. In sandy soils or light loams the seed may be covered somewhat deeper, but not to exceed 1 inch.

Table 2 contains the results of trials made to determine the effect of depth of planting upon stand of plants and yields. The planting was made under the same conditions and the same procedures were followed as described in the study of the effects of the various rates of seeding. All plots were seeded at the uniform rate of 1 ounce per 100 feet of row space.

TABLE 2.—*Effect of depth of planting upon stand of plants and yields per 100 linear feet of row space*

Depth of seeding (inch)	Plants	Yield	Comparative stand	Comparative yield
	Number	*Ounces*	*Percent*	*Percent*
¼	2,294	89.50	100.00	100.00
½	1,931	77.50	84.18	86.59
1	1,283	50.25	55.93	56.15

The results show that the stand of plants and the yields in ounces decreases as the planting depth increases. In this instance, too, the ratio between the stand of plants and the yield is practically identical for all planting depths. Both these results and those presented in table 1 are highly significant as judged by the use of Fisher's method for the analysis of variance (*15*).

SEED TYPES AND GERMINATION

Orach produces four types of seeds, which Becker (*4, pp. 121–131*) has described as follows:

1. Black, strongly arched fruit, arising from pistillate flowers with bracts (without perianth) with vertical seed.
2. Black fruit, arising from pistillate or perfect flowers with perianth (without bracts) with horizontal seed.

3. Yellow-brown fruit, strongly arched, arising from pistillate flowers with bracts (without perianth) with vertical seed.
4. Yellow-brown fruit from pistillate or perfect flowers (without bracts) with horizontal to vertical seed.

A comparison of these types will show that Nos. 1 and 3 are practically identical as to shape and origin and differ noticeably only in color and size. Types 2 and 4 likewise are practically identical except for color and size, but they have an origin different from that of 1 and 3. A suggested explanation for the occurrence of both of these types as black and yellow-brown forms is given on page 19.

The yellow-brown seeds of orach germinate in from 3 to 7 days, depending on the suitability of conditions. Untreated black seed shows delayed germination, but Baar (*1*) and Becker (*4*) have shown that the germination period and the percentage of black seeds germinating can be made to approximate closely that of the yellow-brown seeds by exposing them to light, treating them with dilute nitric acid, or scarifying them with a file. From a practical standpoint, however, untreated black seeds are of little value. Under laboratory conditions, from 8- to 15-percent germination has been secured, but attempts to obtain a stand of plants from seed planted in soil have resulted in almost total failure.

Table 3 gives the results of germination tests conducted in the laboratory. These tests show that a temperature of approximately 68° F. appears to be most favorable for germination. The percentage of seeds germinating at 86° was rather consistently lower, and alternating the temperature by placing the samples in the germinator at 68° for 18 hours and at 86° for 6 hours did not give better results than a constant temperature of 68°.

TABLE 3.—*Germination tests with different varieties of orach*

Variety	Age of seed	Seed cleaned or uncleaned [1]	Germination at—			Days
			68° F.	86° F.	Alternating 68° and 86° F.	
	Months		*Percent*	*Percent*	*Percent*	*Number*
Triumph	24	Cleaned	58	45	48	7
Do	12	do	95	79	88	3
Do	2	do	90	---	---	10
Do	(2)	do	29	81	91	19
Do	(2)	Uncleaned	36	69	69	19
Gelbe	12	do	67	22	---	7
Do	12	Cleaned	80	52	80	7
Deep Blood Red	24	do	37	21	25	7
Do	12	do	43	14	34	7
Lee Giant	12	do	34	26	45	7

[1] Cleaned refers to seed from which the bracts have been removed; uncleaned to seed with bracts intact.
[2] New.

Under field conditions the percentage of seeds germinating is not nearly so great as under the more ideal conditions prevailing in seed germinators. In part this may be due to covering too deeply, especially in heavy soils. Loss from damping-off of the newly sprouted seeds is, however, by far the more important factor. It would seem, in fact, that deep planting is injurious largely because of the excellent opportunity it affords for the action of damping-off organisms.

Table 4 contains the results of experiments to control damping-off by means of various soil and seed treatments. These tests were conducted in the greenhouse, where conditions are even more favorable for damping-off than in the field. Duplicate flats were used in each series, in each of which 1,000 seeds were sown in rills. In the treatments described as "seed dusted" the disinfectant was placed in the package containing the seeds and the package shaken to insure uniform and maximum coverage. In instances where the seed was treated with disinfectant solutions, the treatment consisted in soaking the seeds for 1 hour in the solution before sowing. Soil treatments with solutions consisted in saturating the soil with the solution at the concentration given in the table, after the seed was sown. Soil treatments with dust were accomplished by first opening the rills for the seed, then applying a moderately heavy covering of dust to the entire surface of the flat. The Trioxo K. D. 345 treatment was given as prescribed in the circular accompanying the product.

TABLE 4.—*Results of soil and seed treatments of orach in the greenhouse for the control of damping-off*

[1,000 seeds per flat]

Treatment	Stand of plants				
	Series 1		Series 2		Both series
	Flat 1	Flat 2	Flat 1	Flat 2	
	Number	*Number*	*Number*	*Number*	*Percent*
Semesan (seed dusted)	486	218	727	414	46. 13
Semesan (soil dusted)	95	82	774	748	42. 48
Copper oxide (seed dusted)	101	136	218	328	19. 58
Copper oxide (soil dusted)	82	86	101	216	12. 13
Semesan solution, 0.25 percent (seed treated)	11	39	165	237	11. 30
Mercuric chloride, 1-1,000 (soil treated)	140	138	25	38	8. 53
Semesan solution, 0.25 percent (soil treated)	20	43	100	67	5. 75
Check	14	16	76	110	5. 40
Trioxo K. D. 345 (soil treated)	9	21	50	33	2. 83

It will be seen that even the best treatment resulted in a relatively poor stand of plants. Unpublished data of other trials, however, are in keeping with these and show that the results presented here must be considered in line with what may be expected under environmental conditions similar to those at Cheyenne. It is evident that the average number of plants obtained under most treatments in series 2 is higher than the corresponding number for series 1. This may have been an indirect effect of the higher temperatures existing during the germination period of the first series. Examination of the nongerminating seeds at the time final counts were taken showed that a high percentage of these had actually germinated, but that they had been killed by fungus infection when the hypocotyls were from 5 to 10 mm. long. In the case of the Trioxo K. D. 345 treatment there was evidence of direct injury to the young hypocotyls, and this probably accounts for its relatively poor standing.

Dusting either the seed or the soil with Semesan proved in these experiments to be the most effective treatment against damping-off. Of these two methods, dusting the seed is to be preferred, since a fairly constant quantity of dust is employed and the danger of overapplication is minimized. The relatively poor showing made by dusting the soil with Semesan in series 1 is thought to be due to an overapplication, since there was evidence of injury to the roots of these plants. Copper oxide, used as a dust, appears as a poor second to Semesan in controlling seedling diseases, but it also appears that the relative merits of seed and soil treatments are the same for this material as for Semesan. None of the other treatments gave sufficient control to warrant their recommendation. If control measures against seedling diseases are required for field plantings, dusting the seed as indicated above would appear to be the most practical method to employ.

THINNING, HARVESTING, AND YIELDS

Orach, like spinach, is seeded in rows, but, unlike spinach, the plants should not be thinned until they have reached edible size.

In a method employed with considerable success by many home gardeners, the plants are allowed to grow undisturbed until they are from 4 to 6 inches high. When they have reached this size they are thinned to 3-foot intervals, and the plants removed are used for culinary purposes. The plants left in the row are allowed to grow undisturbed until they have attained considerable size, serving as a continuous source of greens throughout the summer. Harvesting from these plants consists in stripping the young, tender leaves from the tips of the branches and the central portion of the plant. If repeated harvests are to be made, the plants should not be too severely stripped at any one harvest. A good rule to follow is to pick only leaves over 2½ to 3 inches in breadth. The older, coarser leaves near the base of the plant should also be left, as they are too fibrous or tough for high quality. If the plants are not too severely stripped they will blossom and provide an abundance of seed in the fall.

When the crop is raised on a commercial basis, all plants are harvested when from 4 to 6 inches in height, and succession plantings at 2-week intervals are depended upon for a continuous supply.

Estimates or even data as to yields have but limited application because of the many factors affecting yield. De Noter (*33, pp. 9–10*) states that a full-grown plant will yield 2⅘ pounds of edible leaves at a picking. With rows 42 inches apart and plants spaced 3 feet apart in a row, this would give a yield of 9,126 pounds per acre. It is probable, however, that this represents considerably less than the average yield, for Becker (*5*) states that in Germany yields range from 300 to 500 kg. per acre (equivalent to about 26,000 to 44,000 pounds per acre). Results at Cheyenne indicate that yields of from 5,000 to 6,000 pounds per acre are about all that can be expected even under irrigation. These estimates are based on single harvests from mature plants.

USES

Orach is generally prepared for use in much the same manner as spinach. Many persons cook the entire plants if harvested when from 4 to 6 inches high, but the quality of the cooked product is improved by stripping the leaves from the stems before cooking. Even under irrigation the stems of the plants soon become rather tough and woody. Leaves harvested from the branches of mature plants are as tender as the leaves from young plants and require no special treatment to prepare them for use.

Orach greens are very similar to spinach in flavor, but are of a finer and softer texture. In widely distributed trials throughout the Great Plains region various cooperators have been almost unanimous in preferring them to spinach. Those who prefer greens of a slightly acid flavor add a few leaves of broad-leaved sorrel to the orach in cooking. In Europe, and especially in France, where sorrel leaves are held in high esteem, orach is frequently added to the sorrel to reduce the acidity and to improve the color and texture of the cooked product. The broad-leaved sorrel used for this purpose is readily obtainable in this country. It is a perennial plant, entirely hardy, and easily cultivated.

In India, according to Speede (*32*), "the green kinds are boiled as spinach, but the red, which are the most esteemed, are best dressed with butter, and spicy seasoning." The popularity and uses of orach in France are indicated by De Noter (*33, pp. 9–10*), in a letter to the Office of Foreign Seed and Plant Introduction, in which he states that he is sending—

> Seeds of a variety with an exceedingly delicate flavor; it is easy to clean with very little waste. It brings three times the price of ordinary spinach; * * *. It loses only one-fourth of its weight in cooking, while common spinach loses three-fourths of its weight * * *. It makes a delicious salad.

He adds the statement that "The seeds, milled and bolted into flour, make an excellent feed. * * * In Mexico this brown flour is used to make cakes."

Because of its low carbohydrate content, orach is included by Orton (*29*) in the list of vegetables that may be safely eaten by diabetic patients. The analysis of the leaves and stems is as follows (*11*): Water, 88.0 percent; protein, 4.5; fat, 0.4; ash, 2.4; carbohydrates (including fiber), 4.7. De Noter (*33, p. 10*) gives analyses of seeds and stalks as follows:

> Seeds: Protein, 24.62 percent; fat, 6.00; sugar and starch, 53.70; cellulose, 1.92; mineral matter, 3.46; water, 10.30. Stalks (dried): Protein, 3.00 percent; fat, 1.20; sugar and starch, 35.50; cellulose, 46.04; mineral matter, 5.16; water, 9.10.

DISEASES, INSECTS, AND OTHER ENEMIES[6]

Up to the present time the only serious disease that has been reported as affecting orach is the damping-off to which the young seedlings are subject. Since orach is closely related to the beet, however, it may be expected to be subject to the same diseases and therefore should not be planted where beet diseases are known to be present.

Aphids, of several species, are among the most troublesome insect pests of this crop. They are especially troublesome during some seasons, and frequent spraying or dusting with nicotine is necessary for their control. Several different chewing insects often feed on orach and may become especially troublesome to plants that are left standing for the purpose of providing a continuous supply of greens. Several kinds of beetles and caterpillars may do serious damage. None of these, however, are specific for this plant, but they are general feeders. Some of these, such as the flea beetles and the spotted cucumber beetle, may be controlled by treatments with insecticidal sprays or dusts containing derris or cube. The use of stomach poisons, such as paris green, lead arsenate, or fluorine compounds, is not to be recommended on this crop, except in instances where it is absolutely certain that none of the foliage so treated will be used as food.

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[6] For a discussion of insecticides and control measures against aphids and other insects attacking garden vegetables see Farmers' Bulletin 1371, Diseases and Insects of Garden Vegetables, U. S. Department of Agriculture, Washington, D. C.

Grasshoppers may injure the plant severely as well as the edible product. The methods of grasshopper control recommended for the region should be employed.

In sections where rabbits are numerous they constitute one of the most serious animal pests of the crop. They not only eat off the young plants as they emerge from the ground, but they often feed on the older plants sufficiently to injure them. Ground squirrels of various species are also troublesome, since they feed on the newly planted seed and young plants. Gophers, prairie dogs, and even rats and mice may at times injure the crop through their activities. For the control of these and other rodent pests, the grower should consult an agent of the Bureau of Biological Survey, United States Department of Agriculture.

SOURCES OF SEED

Seed of certain of the red varieties of orach is sometimes listed by American seed houses for use as an ornamental, but, so far as known, seed of the green and yellow varieties is not listed for sale in this country. Many European seed houses, however, list three varieties and a few offer four.

European prices for this seed (with bracts on) range from about 20 to 35 cents an ounce and from $12 to $18 per hundredweight. The price varies somewhat from country to country, but more between varieties. Seed of the red varieties usually commands higher prices than that of the green or yellow (white) varieties.

SEED PRODUCTION

CULTURE

Orach apparently is pollinated almost solely by the wind; so, when two or more varieties are to be grown for seed production, care should be taken to space them far enough apart to prevent cross-pollination.

When grown solely for seed production (fig. 3), one-half ounce to 100 feet of row, or 4 pounds of cleaned seed per acre, should be sufficient where single rows spaced 42 inches apart are used. The same method of seeding is employed as when the crop is to be used for culinary purposes.

After the plants are well established, they should be thinned to stand about 3 feet apart in the row if the maximum development is desired. There is some doubt, however, as to whether maximum development should be encouraged in larger plantings where harvesting by machinery is necessary. Cutting and binding is made extremely difficult if the plants reach their full development. The spread of a full-grown plant often exceeds 4 feet, and the basal portion of the stalk may measure 1½ inches in diameter. To avoid this overdevelopment of the plants, a somewhat closer spacing in the rows may be desirable. Allowing the plants to stand from 18 inches to 2 feet apart in the rows will considerably reduce their size, but the most satisfactory distance in any given instance will depend upon the suitability of the soil for the crop and upon the moisture supply.

Even with this closer spacing, water should be applied sparingly during the earlier stages of growth and discontinued entirely about the first of August. The objective of the closer spacing is to dwarf the plants somewhat through competition for water, and if the water is applied much later than the date given, the plants will remain too long in the vegetative state. This prolonged growth not only makes for excessive size, but may prevent much of the seed from maturing properly.

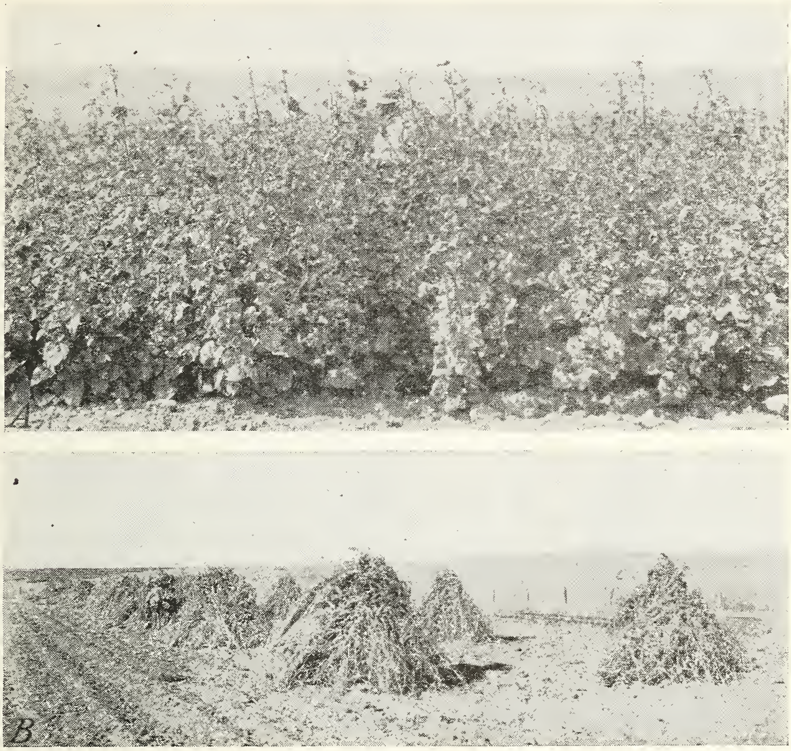

Figure 3.—*A*, Portion of a field of mature orach plants grown for seed production; *B*, same field after the plants have been cut and put in shocks to cure.

In localities having environmental conditions similar to Cheyenne, planting for seed production should be done not later than June 25. Flowering, and consequently seed formation, take place first at the top of the plant and proceed downward through the apical portions of the branches. This first wave of bloom is followed by a second, or perhaps more waves involving the inner or axillary blooms. The duration of this cycle is probably dependent to a large measure on such factors as heat, moisture, and perhaps length of day, but even in the most favorable environment it is a protracted process. Even with a growing season of 132 days, 35 percent of the seed has been found to be either immature or black.

HARVESTING, THRESHING, AND CLEANING SEED

Orach can be harvested for seed with a corn binder, provided the plants have not been allowed to reach their full development. If they are too large to be cut readily with a corn binder, or if the spread of the branches makes binding unsuccessful, hand tools must be used.

After the plants are cut they should be shocked for drying (fig. 7, *B*). Enclosed as it is between two bracts, the seed is very subject to injury by molding or heating if the plants are not thoroughly and quickly dried after cutting. A frost of sufficient severity to cause shedding of the leaves before the plants are cut is desirable, since quick and thorough drying of the plants is facilitated through better aeration of the shocks.

Threshing can be accomplished with a grain thresher of the Baldwin type, or it can be done easily by hand methods. The use of a machine in threshing makes for economy in this process, but adds considerably to the expense and difficulty of cleaning. Even with most or all of the concaves removed from the threshing machine, the stalks are badly broken in threshing. These pieces of broken stalks are difficult to separate from the seeds even with a greatly reduced wind supply to the fanning mill.

The nature of the cleaning process will naturally depend upon the extent to which the seed is to be cleaned. All commercial seed from Europe is sold with the bracts intact. The reason for this practice is not known. The bracts are easily removed in cleaning, and it is greatly to the grower's advantage to have this done by seedsmen.

The bracts of a fully matured orach seed are about one-half inch in diameter, which makes it virtually impossible to sow the seed with a mechanical seeder and renders even hand seeding extremely difficult. The seeds tend to bunch together and are easily blown about by the wind.

The major objection, however, to the sale or use of seed that has not had the bracts removed is that such seed shows a much lower percentage of germination than thoroughly cleaned seed. Table 3 shows that under practically ideal conditions in the laboratory the germination of such seeds may be reduced by 30 percent. Under field conditions the reduction is considerably greater. It is impossible to raise the percentage germinating unless the bracts are removed, because of the very slight difference between the size and weight of the mature seed and of the black and immature seed. After the removal of the bracts, however, the good seeds are easily separated from the others by screening.

The percentage of immature seeds will of course vary from year to year and from one locality to another. Seed setting and ripening is in effect an indeterminate process, since even under the most favorable conditions not all of the seed matures. Thus, almost regardless of when the plants are cut for seed, there will be a certain percentage of immature seed present which can be separated only by screening after the bracts are removed. This can be satisfactorily accomplished only by seedsmen equipped with proper threshing and cleaning equipment, and it is solely by such a cleaning process that the percentage of germination can be increased and guaranteed by seedsmen.

TYPES AND YIELD OF SEED

The ratio of yellow-brown to black seeds is likewise highly variable from year to year and from locality to locality. Environmental conditions at the time seeds are in the formative stage are apparently responsible for the relative number of each that a plant will produce. Under normal conditions all plants bear both types of seeds (fig. 4), and each of these produces plants that are phenotypically alike. Moreover, plants from either the yellow-brown or the black seeds will in turn produce plants that will bear both seed types. Cohn (*12*) in support of this theory offers the following explanation for their occurrence:

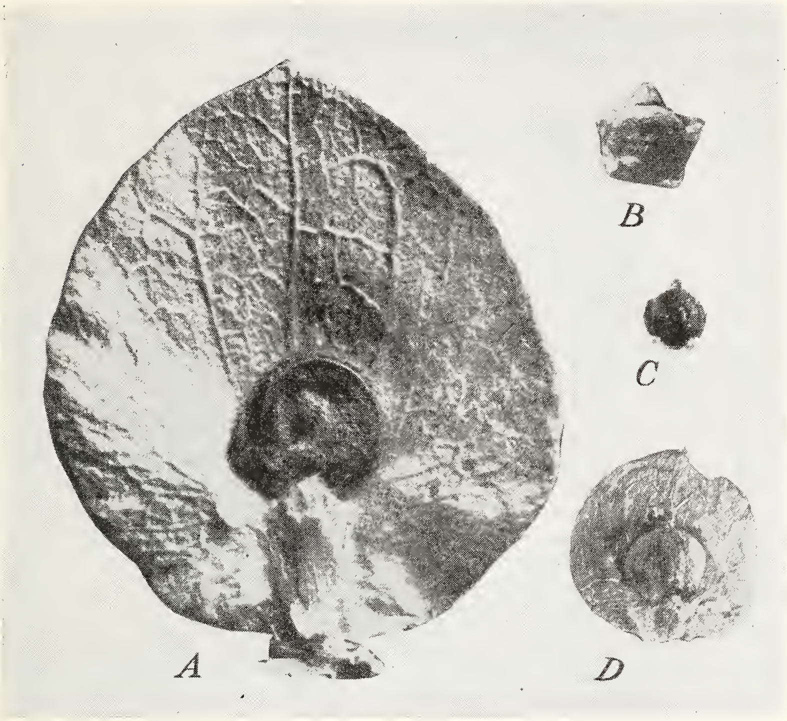

FIGURE 4.—Seed types of *Atriplex hortensis*: *A*, Yellow-brown vertical seed with one bract removed to show type of seed, position in bract, and method of attachment; *B*, yellow-brown horizontal seed enclosed in perianth; *C*, black horizontal seed enclosed in perianth; *D*, black vertical seed with one bract removed to show position and attachment.

> If changes in nutrition occur when the flowers are in a plastic condition, transition forms between the yellow-brown and the black fruits develop. The yellow-brown seeds, which always germinate immediately, develop into stronger plants with correspondingly more seed than the black seeds, which have a pronounced delayed germination. The progeny of these plants produce all seed forms in ratios varying according to the nutritional conditions. Through artificial pruning—removal of the head shoots and the lateral shoots—plants are obtained whose remaining flowers, as a result of better nutrition, produce only yellow-brown fruits. Races that produce only yellow-brown fruits have not yet been found.

The significance of the difference in weight of the different fruit forms is shown in table 5, based on surveys by Cohn (*12*) and Becker (*4*).

TABLE 5.—*Weight of fruit forms of* Atriplex hortensis *according to Becker* (*4*) *and Cohn* (*12*)

Fruit form	Average of 100 according to—		According to Cohn	
	Becker	Cohn	Largest fruit	Smallest fruit
	Milligrams	*Milligrams*	*Milligrams*	*Milligrams*
Yellow-brown	549	275	533	100
Black with horizontal seeds	220	130	133	93
Black, lens-shaped, with vertical seeds	265	178	233	93

The yield of orach seed under irrigation may be expected to range from 3,500 to 4,000 pounds per acre (with bracts intact). Approximately 74 percent of the total weight is lost in removing the bracts, and about 32 percent of the seed thus cleaned will be lost through screening. The total percentage lost from all causes during the cleaning process may be expected to amount to about 80 percent of the total yield, leaving a mean yield of from 600 to 700 pounds of thoroughly cleaned seed per acre.

Orach seed with bracts intact will average about 2,500 seeds per ounce; thoroughly cleaned seed will average about 4,500 per ounce. The weight of the former averages approximately 9 pounds and of the latter about 50 pounds per bushel. These data represent averages for samples of seed collected from various sections of the central Great Plains area; and since both the size and weight of the seed from these places showed considerable variation, they are indicative only of what may be expected from seed produced in this region.

Under suitable storage conditions the seed retains its vitality for from 3 to 5 years.

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